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(चौथा पुनरीक्षण)

Titanium Dioxide, Anatase, for Paints — Specification

(Fourth Revision)

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Raw Materials for Paints, Varnishes and Related Product Sectional Committee, CHD 21

FOREWORD

This Indian Standard (Fourth Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Raw Materials for Paints, varnishes and related product Sectional Committee had been approved by the Chemical Division Council.

This standard was first issued in 1953 and subsequently revised in 1968 and 1981. In the second revision, titanium dioxide pigment, rutile type was excluded and method for determination of relative density included. But at the same time relative density was not prescribed as the basis for a quantitative assay of two types of pigment, namely, anatase and rutile. Further, titanium dioxide content was increased from 96 to 97·5 percent by mass. The standard also achieved substantial alignment with ISO 591 : 1977 'Titanium dioxide for paints' issued by the International Organization for Standardization (ISO). Following this, in the fourth revision three additional requirements for example, volatile matter at 105°C after 24 h preconditioning, resistivity of aqueous extract and scattering power of titanium dioxide have been incorporated with reference to ISO 591 : 2000.

Though the two types of titanium dioxide pigment are identical in chemical composition, they differ in crystal structure and other physical properties. The determination of relative density provides a useful indication for distinguishing the two types, but X-ray diffraction is the only method which can clearly and conclusively identify the two types.

The rutile type has separately been covered in IS 9788: 1981 'Specification for titanium dioxide, rutile, for paints'.

The list of experts who had made significant contribution to the formulation of this standard is given at Annex F.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

TITANIUM DIOXIDE, ANATASE, FOR PAINTS — SPECIFICATION

(Fourth Revision)

1 SCOPE

This standard prescribes the requirements and methods of sampling and test for titanium dioxide, anatase, used as a pigment in the paint industry.

2 REFERENCES

The Indian Standards given below contain provisions which through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards.

IS No.	*Title*
33 : 1992	Inorganic pigments for paints — Methods test and extenders of sampling and (*third revision*)
1070 : 1992	Reagent grade water (*third revision*)
1303 : 1983	Glossary of terms relating to paints (*second revision*)

3 TERMINOLOGY

For the purpose of this standard, definitions given in IS 1303 shall apply.

4 REQUIREMENTS

4.1 Description

It shall be a soft, dry powder and shall consist essentially of titanium dioxide of anatase crystal structure. If agreed to between the purchaser and the manufacturer, it shall be determined by X-ray diffraction method as prescribed in Annex A.

4.2 Composition

The material, after drying, as given in **8** of IS 33 to constant mass, shall contain not less than 98 percent of titanium dioxide when determined by the method prescribed in Annex B.

4.3 The material shall also comply with the requirements given in Table 1.

5 PACKING AND MARKING

5.1 Packing

The material shall be suitably packed in moisture proof packing as agreed to between the manufacturer and the purchaser.

5.2 Marking

The packages shall be marked with the following particulars:

a) Name of the material;
b) Indication of the source of manufacture;
c) Mass of the material;
d) Batch No. or lot No. in code or otherwise; and
e) Month and year of manufacture.

6 SAMPLING

6.1 Representative samples of the material shall be drawn as prescribed under **5** of IS 33.

6.2 All the characteristics prescribed in this standard shall be tested on the composite sample.

6.3 Criteria for Conformity

The lot shall be declared as conforming to the requirements of this standard if all the test results on the composite sample satisfy the relevant requirements prescribed in **4**.

7 QUALITY OF REAGENTS

Unless specified otherwise, pure chemicals and distilled water (*see* IS 1070) shall be employed in tests.

NOTE — 'Pure chemicals' shall mean chemical that do not contain impurities which affect the results of analysis.

Table 1 Requirements for Titanium Dioxide, Anatase for Paints

(*Clause* 4.3)

Sl No. (1)	**Characteristic** (2)	**Requirement** (3)	**Method of Test, Ref to Cl No. in IS 33 : 1992** (4)	**Annex** (5)
i)	Titanium dioxide content Percentage by mass, *Min*	98	-	B
ii)	Volatile matter at 105 ± 2°C percent by mass, *Max*	0.5	8	-
iii)	Residue on 45 micron IS sieve, percent by mass, *Max*	0.1	9	-
iv)	Oil absorption, percent by mass (*see* Note 1)	15 to 30	10	-
v)	Colour	Close match to the approved sample	11	-
vi)	Reducing power	Not inferior to the approved sample	15	-
vii)	Relative density at 27°C	3.7 to 3.9	16	-
viii)	Matter soluble in water, percent by mass, *Max*	0.5	19 (*see* Note 2)	-
ix)	*p*H of pigment slurry (without filtering) at 27°C	6 to 8	21	-
x)	volatile matter at 105°C after 24 h preconditioning at (23 ± 2)°C and (50 ± 5) percent relative humidity percent age by mass (max).	0.5	8	-
xi)	resistivity of aqueous extract (Ω.m), *Min*	80	-	C
xii)	Scattering power of titanium dioxide (percent), compared with standard sample, *Min*	105	-	D

NOTES:

1 This shall, however, be within ±10 percent of the approved sample, if any.

2 When a clear filtrate is not obtained in the test procedure, it shall be centrifuged before separation and evaporation of filtrate to determine matter soluble in water.

ANNEX A

(*Clause* 4.1)

DETERMINATION OF TITANIUM DIOXIDE, ANATASE, CRYSTAL STRUCTURE, BY X-RAY DIFFRACTION

A-1 OUTLINE OF THE METHOD

The X-ray diffraction pattern obtained from a material is characteristic of that material. The intensity of a diffraction peak is entirely dependent upon the amount of that substance present and to a minor extent the peak intensity of the component is also dependent on the mass absorption co-efficient of other materials present. The intensity of diffraction maxima for anatase and rutile is measured by X-ray diffractometry. The intensity of the anatase peak is converted to anatase content relative to rutile and the rutile content is determined by difference. The X-ray diffraction measurement is made on single pigments, pigment mixtures, on films of pigmented coatings and on films prepared from liquid coatings if interfering materials are not present. When interfering materials are present, the pigment is separated from the resolubilized (or ignited) film or from the liquid coating and treated to isolate the titanium dioxide.

A-2 APPARATUS

A-2.1 X-Ray Diffractometer

The principle components of this instrument are:

(a) X-ray generator, (b) Copper target X-ray tube, (c) Goniometer, (d) Detector, and (e) Electronic circuit panel and strip chart recorder.

A-2.2 Operating Conditions

The X-ray tube voltage and filament current and other settings are selected to record X-ray diffraction peaks of weak intensities.

A-2.2.1 *Nickel Filter*

A nickel filter should be used to remove Cu K beta radiation if a monochromator is not used. Cu K beta radiation will produce a diffraction line from the rutile phase of TiO_2 that appears at the same 20 angle as the anatase analytical line.

A-2.3 Typical Apparatus Conditions

A-2.3.1 *High-Voltage Power Supply*

Select X-ray tube voltage, filament current, and other settings so that 0.1 percent anatase generates a signal four times the noise level.

A-2.3.2 *Detector*

Scintillation detector operating at optimum voltage.

A-2.3.3 *Pulse Height Analyzer*

Settings will depend on instrumentation used.

A-2.3.4 *Chart-Speed* — 12.5 mm/min.

A-2.3.5 *Goniometer Scanning Speed* — 1/4°/min.

A-2.3.6 *Time Constant* — 5.

A-2.3.7 *Scanning Range, 20* = 28 to 24°.

A-2.3.8 *Scale Factors*

For samples of low anatase content, a scale factor of 100 counts full scale is normally used for the 20 = 26 to 24° range (anatase diffraction maximum), and a scale factor of 5 000 counts full scale is normally used for the 20 = 28 to 26° range (rutile diffraction maximum). The scale factors may be changed depending on the level of anatase expected in the sample.

A-3 REAGENTS

A-3.1 Purity of Reagents

Untreated rutile and anatase grades of titanium dioxide pigments are used to make synthetic standards for calibration. The crystalline structures of the reagents must be 100 percent rutile and 100 percent anatase as determined by examining these materials by X-ray diffraction.

A-3.2 Mixing Reagents

A series of rutile standards of varying rutile content are prepared to cover the range of interest by thoroughly mixing known amounts of 100 percent rutile and 100 percent anatase together. The pigments are dispersed in a solvent, such as isopropyl alcohol and then mixed, followed by air drying. This dry cake is ground up using a mortar and pestle to ensure homogeneity.

A-4 INTERFERENCES

A-4.1 Calcium sulphate interferes but its effect is eliminated by chemical removal. It is desirable to ensure by analysis that any residual calcium sulphate is considerably lower than the level of anatase being sought. The insoluble residue after removal of calcium sulphate should be ignited above 700°C. Chrome yellow and the valentinite form of antimony trioxide also interfere if not removed. Excessive amounts of iron render analysis difficult due to increased background (*see* Note). Additives, such as antimony and zinc, and impurities, such as niobium and zirconium, are generally present in solid solution and thus would not have interfering diffraction peaks. Surface elements such as silica and alumina, do not interfere. Extreme differences in particle size between the anatase and rutile portions affect the results.

> NOTE — Background scatter due to high iron levels in a sample may be reduced by use of a cobalt or molybdenum target tube in place of the copper target tube. The background may be eliminated for all practical purposes by use of a curved crystal monochromator equipped with a graphite crystal in conjuction with a copper target tube.

A-4.2 In the calculation of converting the ratio to percent, it is implicitly assumed that the sum of anatase and rutile is 100 percent an assumption normally made in TiO_2 pigment systems. Other materials present would interfere to the extent that they dilute the sample. The third polymorphic form of TiO_2, brookite, would have such an effect. However, it reportedly does not occur in commercial titanium dioxide pigments.

A-5 SAMPLE PREPARATION

A-5.1 Packing the pigment in the specimen holder, and obtaining a smooth surface is one of the most important phases in X-ray analysis. Ripples or indentures in the specimen surface cause variations in the test because of an error of eccentricity and a change in the intensities of the peaks. The change of preferred orientation of pigmentaryTiO_2 is remote because of its small particle size.

A-5.1.1 Pack the pigment in a die suitably constructed to accommodate the specimen holder for goniometer. Apply constant pressure with a hydraulic press (*see* Note). Alternatively, place the specimen holder on a flat, smooth, firm surface and pack the specimen into the opening by applying constant and firm pressure with a flat blade.

> NOTE — Use of a set procedure with a hydraulic press will improve specimen preparation uniformity compared to hand-packed specimens. This is particularly true where more than one person is involved in specimen preparation.

A-5.1.2 *Coating on Metal Panels*

Cut the coated panel into the proper shape and size to fit au adjustable specimen holder and analyze without further preparation. This assumes that interferences are not present.

A-5.2 Liquid Coating Samples

A-5.2.1 Liquid coating samples not containing interfering materials are analyzed as cast film of the total paint on aluminium or other suitable substrate. A 25 to 50 µm: (1 to 2 ml) dry film thickness is adequate.

A-5.2.2 Liquid paint samples containing interfering materials must not be analyzed until the interfering components are removed. This can be accomplished by centrifuging to separate the total pigment. The separated pigment is treated to remove interfering components.

A-6 PROCEDURE

A-6.1 Record the X-ray diffraction maxima of the anatase and of the ruffle peak by scanning the range between 20 = 26 to 24° and 20 = 28 to 26°, respectively. Scan each range twice.

A-6.2 Measure the peak maxima in chart units for the anatase and rutile peaks. Draw the baseline between the lowest points of the trace on each side of the peak. Average the peak maxima of the duplicate runs and convert chart units into counts per second.

A-6.3 Since only ratios are used, the chart units need only be corrected for differences in the scale factors used for the two peaks. Any consistent units can be used, not just counts per second.

A-6.4 Prior to and after analyzing the unknown sample, analysis of one of the standards should be made to establish instrument stability over a period of time.

A-7 CALCULATION

A-7.1 Calculate the anatase level relative to rutile from the intensities above background as follows:

$$\text{Percent anatase} = \frac{1}{1+k\frac{Ir}{Ia}} \times 100$$

Where,

l_r = net intensity of rutile diffraction maximum;

l_a = net intensity of anatase diffraction maximum; and

K = slope of calibration curve when intensity ratio l_a/l_r is plotted against mass ratio $M_a/M_r$and equals (l_a/l_r)/ (M_a/M_r).

Where,

M_a = mass or anatase, and

M_r = mass of rutile.

A-7.2 The value of the constant in the intensity-concentration equation is determined for individual instruments with standards in the concentration range of interest. Routine instrument-calibration procedures are followed.

ANNEX B

(*Clause* 4.2)

DETERMINATION OF TITANIUM DIOXIDE

B-1 GENERAL

Three methods for determination of titanium dioxide have been prescribed. In case of dispute, method 1 shall be applicable.

B-2 METHOD 1 : ZINC REDUCTION METHOD

B-2.1 Outline of the Method

A solution of the dry pigment is made with concentrated sulphuric acid and ammonium sulphate. Titanium is reduced with zinc amalgam in Nakazono reductor and the resulting trivalent titanium is titrated with ferric alum.

B-2.2 Reagents

B-2.2.1 *Concentrated Sulphuric Acid* — Relative density 1.84.

B-2.2.2 *Ammonium Sulphate*

B-2.2.3 *Zinc Amalgam* — 3 percent. Place 50 ml of mercury in a small porcelain dish on a hot water-bath, covering the surface of mercury with 2 percent (*m/v*) sulphuric acid. Add about 25 *g* of zinc in small granules. Stir from time to time and replenish the dilute acid with water as required. When all the zinc has disappeared, allow the amalgam to cool and stand for several hours. Finally filter through a Gooch crucible with no asbestos pad. Store the amalgam in a glass bottle under2 percent (*m*/*v*) sulphuric acid.

B-2.2.4 *Standard Ferric Ammonium Sulphate Solution* — 0.062 5 N. Standardize as given in **B-2.2.4.1.**

B-2.2.4.1 Transfer by a pipette 50 ml of the ferric ammonium sulphate solution to be standardized to the Nakazono reductor(*see* Fig. 1) prepared ready for use as described in **B-2.4.2.** Displace the air in the reductor by passing carbon dioxide for 3 min. Close the taps B and C. Bring the amalgam into intimate contact with ferric ammo-mum sulphate solution by shaking the apparatus vigorously for 5 min. Place the apparatus on a ring stand. Drain the amalgam and pass inert gas as prescribed under **B-2.4.4** Titrate this against standard potassium permanganate solution. The end point is the appearance of light pink colour persistent for 30 s at least. Calculate the strength of the ferric ammonium sulphate solution as follows:

$$\text{Strength of ferric ammonium sulphate solution} = \frac{V \times 0.1}{50}$$

Where,

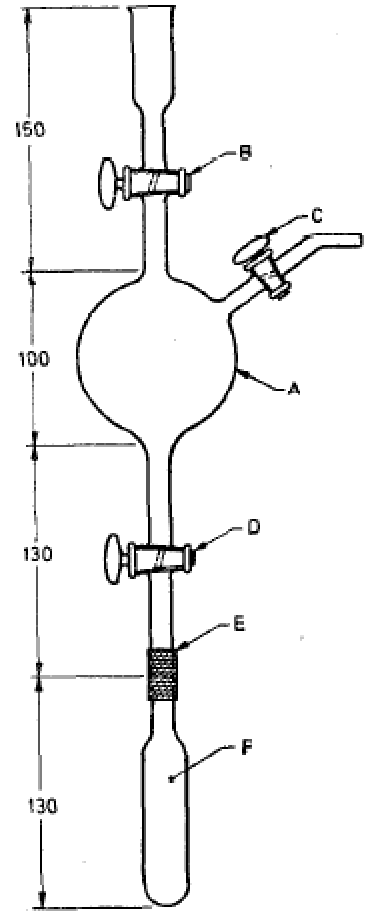
V = volume, in ml, of 01 N potassium permanganate solution required for titration.

B-2.2.5 *Potassium Thiocyanate Solution* — 10 percent (*m*/*v*).

B-2.3 Apparatus

B-2.3.1 *Nakazono Reductor*

The apparatus, as shown in Fig. 1, consists of a bulb *A* with a capacity of 500 ml with three stopcocks *B, C* and *D* attached. To the stopcock *D* may be attached, by means of thick rubber tubing *E,* a small cylindrical flask *F* of about 50 ml capacity. The stopcock *C* which is smaller in bore than either of the other two serves to admit carbon dioxide or nitrogen.



All dimensions in millimetres.

FIG. 1 NAKAZONO REDUCTOR

B-2.4 Procedure

B-2.4.1 Weigh approximately 0.5 g of the dried material to the nearest 0 ·1 mg and transfer to a 250 m1 beaker. Add 20 ml of concentrated sulphuric acid and 10 g of ammonium sulphate. Mix carefully and heat on a hot plate to fuming and then over a strong flame until solution is complete, observing caution while examining the solution. Cool the solution, dilute with 100 ml of water, stir and filter, if necessary.

B-2.4.2 Open stopcock *C,* transfer sufficient quantity of 4 percent sulphuric acid to fill the bottom flask and leave no air space below the stopcock *D* Close tap *D* and add 20 ml of zinc amalgam to *A.* The reductor is now ready for use.

B-2.4.3 To the amalgam contained in *A,* transfer the solution, warmed to 50'C, which shall not exceed 300 ml in volume. Then pass carbon dioxide or nitrogen for about 3 min. Close taps *B* and *C* and simultaneously disconnect the carbon dioxide supply. Bring the amalgam into intimate contact with the solution by shaking the apparatus vigorously for 5 minutes, holding it in such a way that the stopcocks are kept shut and in position. The rate of reduction is apparent from the development of the characteristic violet colour of the trivalent titanium.

B-2.4.4 Place the apparatus on a ring stand. Open stopcock *D* slightly and allow the amalgam to flow slowly into *F.* Close *D* immediately as soon as the amalgam has been completely transferred. With taps *B* and *D* open, pass inert gas through *D* as before, add 10 ml of potassium thiocyanate solution and titrate with standard ferric ammonium sulphate solution until a faint pink colouration persists for one minute.

B-2.4.5 Facilitate the titration by attaching a piece of very narrow glass tubing to the top of the burette with a piece of rubber tubing. The extension passes through stopcock *B* into the bulb *A.*

B-2.5 Calculation

Calculate the titanium dioxide content of the material as follows:

$$\text{Titanium dioxide content, percent by mass} = \frac{V \times 0.005}{M} \times 100$$

Where,

V = volume, in ml, of standard ferric ammonium sulphate solution required; and

M = mass, in g, of pigment taken.

B-3 METHOD 2 : ALUMINIUM REDUCTION METHOD

B-3.1 Outline of the Method

This method is similar to zinc reduction method but easier and quicker to operate. Titanium is reduced to trivalent state by aluminium and titrated against ferric ammonium sulphate using ammonium thiocyanate as indicator.

B-3.2 Apparatus

B-3.2.1 *Delivery Tube*

Made of about 4 mm internal diameter glass tube bent in such a way as to have a horizontal run of about 150 mm and vertical drop of about 75 mm at one end, and a vertical drop of about 150 mm at the other end.

B-3.2.2 *Long Necked Flask* — 500-m1 capacity.

B-3.3 Reagents

B-3.3.1 *Ammonium Sulphate*

B-3.3.2 *Sulphuric Acid — R*elative density 1.84.

B-3.3.3 *Hydrochloric Acid* — Relative density 1.19.

B-3.3.4 *Aluminium Foil* — Electrolytic grade.

B-3.3.5*Sodium Bicarbonate Solution* — Saturated.

B-3.3.6 *Ammonium Thiocyanate Indicator Solution* **—** Prepare by dissolving 24.5 g of ammonium thiocyanate in 80 ml of hot water. Filter, cool to room temperature, dilute to 100 ml and preserve in well stoppered, amber coloured bottle.

B-3.3.7 *Standard Ferric Ammonium Sulphate Solution* — Prepare by dissolving 30.16 of fresh ferric ammonium sulphate [$FeNH_4(SO_4)_2.12H_2O$] in 800 ml of water containing 15 ml of concentrated sulphuric acid. Add …N potassium permanganate solution until a very slight pink colour is obtained. Dilute to 1 000 ml and mix thoroughly. Filter, if necessary. Standardize with 0.190 to 0.210 g of standard titanium dioxide as prescribed in **B-2.3**and calculate titanium dioxide equivalent of solution in grams of titanium dioxide per ml of solution as given below:

$$\text{Titanium dioxide equivalent} = \frac{M \times P}{V \times 100}$$

Where,

M = mass in g, of standard titanium dioxide taken for test;

P = percentage of titanium dioxide in standard dioxide used; and

V = volume in ml, of ferric ammonium sulphate solution required for filtration.

B-3.4 Procedure

B-3.4.1 Weigh accurately 0190 to 0’210 g of the dry material and transfer the same to a 500 rul long necked flask. Add 7 to 9 g of ammonium sulphate and 20 ml of sulphuric acid. Mix carefully, heat on a hot plate to fuming and then over a strong flame until solution is complete. Cool and add 120 ml of water and 20 ml of hydrochloric acid. Boil the contents and remove from heat.

B-3.4.2 Insert the short end of the delivery tube into one hole of a two-hole rubber stopper suitable for the long necked flask. Insert a glass rod with a hook at the bottom end in the other hole in such a way that the bottom end shall be nearer to the bottom of the flask when the stopper is fitted into the flask. Attach 1 g of aluminium foil to the bottom end of the rod by coiling it around the rod. Insert the stopper carrying the rod with foil and delivery tube into the flask in such a way that the foil is near the bottom of the flask at the same time that the long end of the delivery tube is near the bottom of a 250 m1 beaker containing about 150 ml of sodium bicarbonate solution.

B-3.4.3 Heat the flask as soon as the dissolution of aluminium is complete to gentle boiling for 3 to 5 min without disturbing the assembly. Cool to 60’C by partial immersion in water and siphon the sodium bicarbonate solution into the flask giving an atmosphere of carbon dioxide over the reduced titanium solution. Withdraw the stopper, rinse the glass rod attached to it with a little of water, catching the rinsings in the flask. Add 2 ml of ammonium thiocyanate indicator solution and titrate immediately against standard ferric ammonium sulphate solution to a straw coloured end point.

B-3.5 Calculation

B-3.5.1 Calculate the percentage of titanium dioxide as follows:

$$\text{Titanium dioxide, percent} = \frac{V \times E \times 100}{M}$$

Where,

V = volume in ml, of ferric ammonium sulphate solution used in test;

E = titanium dioxide equivalent (*see* **B-3.3.7**) of ferric ammonium sulphate solution in g/ml; and

M = mass in g, of material taken for test.

B-4 METHOD 3 : GRAVIMETRIC METHOD

B-4.1 Outline of the Method

This method is applicable for determination of titanium dioxide content for anatase as well as rutile. Also, this method may be used to determine titanium dioxide content in pigments extracted from the paint where interference of elements like iron, zirconium, vanadium, molybdenum, tungsten, tin, antimony and bismuth is absent.

B-4.2 Principle

Titanium dioxide is dissolved in concentrated sulphuric acid in presence of ammonium sulphate. The undissolved siliceous matter is filtered. The filtrate is made alkaline with ammonia to precipitate titanium as titanium hydroxide. The precipitate is dissolved in hydrochloric acid and re-precipitated selectively through complexing with cupferron reagent. The complex is separated by filtration and then ignited to residue as titanium dioxide.

B-4.3 Apparatus

B-4.3.1 *Glass Beaker*, 500 ml and 1 litre.

B-4.3.2 *Watch Glass*

B-4.3.3 *Silica Crucible*, 50 ml.

B-4.3.4 *Desiccator*

B-4.3.5 *Electronic Balance,* accuracy up to 1 mg.

B-4.3.6 *Hot Plate*

B-4.3.7 *Muffle Furnace*

B-4.4 Reagents

B-4.4.1 *Concentrated Sulphuric Acid*

B-4.4.2 *Ammonium Sulphate*

B-4.4.3 *Hydrochloric Acid Solution,* 1:1 diluted with water.

B-4.4.4 *Ammonia Solution,* 1:1 diluted with water.

B-4.4.5 2 *Percent Aqueous Solution of Ammonium Chloride*

B-4.4.6 3 *Percent Aqueous Solution of Cupferron Reagent,* freshly prepared and filtered.

B-4.4.7 *Methyl Orange Indicator*, 1 percent in alcohol.

B-4.5 Procedure

Weigh about 0.2 g of titanium dioxide sample to nearest 1 mg accurately into a 500-ml beaker, add 25 ml of concentrated sulphuric acid and 20 g of ammonium sulphate. Cover the beaker with a watch glass and heat strongly over a hot plate until a clear yellowish solution is obtained. This process takes about 30 min and is performed in a fume-cupboard. On cooling, the solution becomes colourless. Dilute the solution with 300 ml distilled water cautiously. Warm the solution and filter through a Whatman No. 40 filter paper in a 1 l beaker. To the filtrate, add a few drops of methyl orange indicator and make the solution alkaline by addition of 1:1 ammonia solution till yellow colour is observed. Boil the solution and filter through Whatman No. 41 filter paper and collect the precipitate of titanium hydroxide. Wash the precipitate with 1 percent solution of ammonia and transfer to a 500 ml beaker. Dissolve the precipitate in 100 ml of 1:1 hydrochloric acid and warm the solution. After warming dilute to 300 ml with distilled water; cool to 15°C. Treat the solution with 50 m of filtered aqueous solution of 3 percent cupferron reagent to give yellow flocculant precipitate.

Filter the precipitate through filter paper No. 41 (Whatman) and wash the precipitate with 2 percent ammonium chloride solution.

Place the precipitate along with filter paper in a previously dried and weighed crucible and heat on hot plate to dry. Ignite and incinerate the dried precipitate in a muffle furnace initially at 200°C for half an hour and raise the temperature within 600 to 700°C and maintain for an hour. Cool the residue in desiccator and weigh. Heat and cool the residue till a constant mass is obtained.

B-4.6 Calculation

$$\text{Titanium dioxide, percent} = \frac{\text{Mass of the residue} \times 100}{\text{Mass of the sample}}$$

ANNEX C

DETERMINATION OF RESISTIVITY OF AQUEOUS EXTRACT

C-1 OUTLINE

This method of test can be used for determining the electric resistivity (specific electric resistance) or the specific electric conductivity of the aqueous extract of a sample. The resistivity of the aqueous extract of a pigment is considered as a property which is independent of the amount of water-soluble matter.

C-2 REAGENTS

C-2.1 Water, specific resistivity not less than 2 500 Ω · m or specific conductivity below 4 µS/cm, respectively.

C-2.2 Ethanol, specific resistivity preferable not less than 2 500 Ω · m or specific conductivity below 4 µS/cm, respectively.

C-2.3 Conductivity calibration solution (for example, potassium chloride).

C-3 APPARATUS

C-3.1 Centrifuge, or ultra-centrifuge, if necessary.

C-3.2 Filter Paper, finely textured.

C-3.3 Cylinder, approximately 35 mm wide by 125 mm high, or other container suitable for use with the conductivity cell.

C-3.4 Conductivity Meter, with temperature measurement and its compensation.

C-3.4.1 *Preparation of the Conductivity Meter*

The conductivity meter and the conductivity cell are calibrated using a suitable conductivity calibration solution. In case of insufficient congruence of equipment display and calibration record, the measuring equipment shall be adjusted by correcting the cell constant K.

C-3.5 Conductivity cell, having a cell constant K of approximately 1.

C-4 PROCEDURE

An aqueous extract of a sample shall be prepared before performing the conductivity measurement.

The water-wettability of the sample shall be tested beforehand. In case of low wettability, the sample shall be wetted using as much ethanol as necessary to obtain a soft paste. This paste is subsequently transferred into a suspension by adding water.

The concentration of the suspension shall be adjusted in the range of 5 percent to 10 percent (mass fraction).

For the extraction process, the suspension shall be heated up. The heating time depends on the temperature applied: 100°C for 5 min, 60°C for at least 30 min. For homogenization, the suspension shall be stirred or shaken continuously. A cold extraction at room temperature is also possible. If used, this should be included in the test report with the extraction duration.

Loss of mass during the warm extraction shall be adjusted by adding water to keep the sample concentration at a constant level.

Filter the suspension after tempering through a fine textured filter paper **(3.2).** Separation of solid content may also be done by a centrifuge using clean test-glasses. In this case, the overlaying liquid is to be filtered through a filter paper by decanting.

For performing the measurement, fill the obtained filtrate into the cylinder **(3.3)** and place the conductivity cell in it. Move the cell slowly up and down to remove all air bubbles.

The temperature of determination should preferably be 23°C but a different temperature can be used provided that the necessary corrections are made to take account of the differences in temperature. Other measuring temperatures shall also be reported.

Adjust the temperature slowly to 23°C. The measuring cell shall be adjusted upright in the middle of the cylinder, the measuring opening (vent) around 10 mm below the surface of the liquid. Subsequently, the measurement can be started at (23.0 ± 0.5)°C.

In case the conductivity of the water is applied without the sample and after being flown through the filter is larger than that given in **C-2.1**, this result can be used as blank value. The result of the conductivity measurement is then given by the difference of the conductivity of the filtrate and the water (blank value). The resistivity is the reciprocal value of the conductivity.

ANNEX D

DETERMINATION OF RELATIVE SCATTERING POWER OF TITANIUM DIOXIDE

D-1 DEFINATIONS

D-1.1 Scattering Power

The ability of a pigment to diffuse incident light, thereby having the power to confer opacity and lightness to, for example, a paint in which it is incorporated.

D-1.2 Spectral Scattering Coefficient S(λ)

The net transfer of spectral radiant flux of wavelength in the outward direction from an elementary layer within a body of material illuminated from outside, divided by the product of the thickness of the layer and the difference between the magnitude of the flux in the two directions through the layer (Kubelka-Munk analysis).

D-1.3 Scattering Index S_p(λ)

The spectral scattering coefficient of the sample binder divided by the sample concentration C_m:

$$S_p(\lambda) = \frac{S(\lambda)}{Cm} \qquad \ldots\ldots\ldots..(1)$$

D-1.4 Relative Scattering Power S(λ)

The ratio of the scattering index of the test sample Sp_1 (λ) to that of an agreed reference pigment $Sp_2(\lambda)$ expressed as a percentage:

$$S_r(\lambda)=\frac{S_{p1}\lambda}{S_{p2}\lambda} \times 100 \qquad \ldots\ldots\ldots(2)$$

D-1.5 Reflectance Factor R_∞ The ratio of the radiant flux reflected in the directions within a given cone by a paste or a paint film to that reflected in the same directions by a perfect reflecting diffuser identically irradiated, when the thickness of the paste or the paint film is such that further increase in thickness gives no further change in the ratio.

D-1.6 Reflectivity Q_∞ The reflectance of a paste or a paint film of such thickness that further increase in thickness gives no further change in reflectance.

The reflectivity Q_∞*, corrected according to equation, is related to K/S by the equation:

$$\frac{K}{S} = \frac{(1-Q_\infty^*)^2}{Q_\infty^*} \qquad \ldots\ldots\ldots(3)$$

Value of K/S as a function of 100 Q_∞ or 100 R_∞ are given in Annex A.

D-2 PRINCIPLE

Equal masses of a test sample p_3 and of an agreed reference pigment p_4 are separately dispersed in the same mass of the same black pigment paste. The reflectivity Q_∞ or the reflectance factor R_∞ of each dispersion is measured photometrically at 550 nm or using a Y-filter. From the corresponding values of K/S, the relative scattering power, S_r of the test sample, is given by the equation:

$$S_r = \frac{K/S_{p2}}{K/S_{p1}} \times 100 = \frac{S_{p1}}{S_{p2}} \times 100 \qquad \ldots\ldots\ldots(4)$$

Where,

K/S_{p1} = the *K*/*S* value corresponding to Q_∞ or R_∞ of the test sample; and

K/S_{p2} = the *K*/*S* value corresponding to Q_∞ or R_∞ of the reference sample.

D-3 DETERMINATION OF RELATIVE SCATTERING POWER

D-3.1 Test Sample Dispersion

Take a quantity of the test sample, such that

$$m = 0.478\ Q_\infty$$

Where,

m = the mass in grams, of the sample;

Q_m = the density in grams, per milliliter of the sample; and

0.478 = a conversion factor, expressed in millilitres.

NOTE — The value of this factor is chosen to give a volume concentration of 17% with titanium dioxide.

Weigh 2.5 g of the black pigment paste and the calculated mass of the test sample. Place the black pigment paste in the centre of the lower plate of the automatic muller. Sprinkle the test sample on to the black paste and mix together, using the minimum of effort with the aid of a spatula. Distribute the paste at several points at a distance of about 35 mm from the centre of the lower plate or spread within a ring with an internal diameter of 40 mm and on an external diameter of 100 mm.

Clean the spatula as much as possible by wiping it on the upper plate of the muller.

Close the plates of the muller and grind the mixture in four stages of 25 revolutions under a force of 1.0 ± 0.2 kN. After each stage, collect the paste with the spatula from both plates and spread it as described above on the lower plate, wiping the spatula on the upper plate as before.

NOTES:

1 It is advisable to lay a paper ring of requisite shape as a pattern beneath the glass plate.

2 A different grinding force may be applied by agreement between the interested parties, but should be stated in the test report.

D-3.2 Reference Pigment Dispersion

With the agreed reference sample, repeat the dispersion procedure described above in **D-3.1**, using the same mass m of the agreed reference sample as calculated for the sample under test and the same mass of the black paste.

D-3.3 Preparation of Test Films

Place the test sample and the reference sample in the paste film holders, ensuring that the exposed surface is uniform and levelled.

D-3.4 Measurement of Q_∞ or R_∞

Measure Q_∞ or R_∞ of each film either with a spectrophotometer using a wavelength of 550 nm or with a tristimulus colorimeter using a Y-filter. Both measuring geometries including and excluding gloss are suitable.

If a tristimulus colorimeter is used, note the reading and divide it by 100 to obtain the value of Q_∞ or R_∞.

D-3.5 Expression of Results

From the measured values of Q_∞ or R_∞ obtain the corresponding values of K/S as given in Annex E. If the measured value of Q_∞ or R_∞, includes gloss, subtract 0.04 before using the table in Annex A. Calculate the relative scattering power of the test sample from equation (**D-2**), expressed as a percentage of that of the agreed reference sample.

ANNEX E

K/S Values as a Function of Measured ϱ_∞ or 100 R_∞

100 ϱ_∞ or 100 R_∞	*K*/*S*	100 ϱ_∞ or 100 R_∞	*K*/*S*	100 ϱ_∞ or 100 R_∞	*K*/*S*
0.1	191.301 468	3.9	4.270 945	7.7	1.883 001
0.2	95.302 643	4.0	4.149 022	7.8	1.852 069
0.3	63.303 25	4.1	4.033 100	7.9	1.821 942
0.4	47.305 222	4.2	3.922 750	8.0	1.792 594
0.5	37.706 482	4.3	3.817 581	8.1	1.763 991
0.6	31.307 755	4.4	3.717 244	8.2	1.736 110
0.7	26.737 595	4.5	3.621 411	8.3	1.708 921
0.8	23.310 287	4.6	3.529 794	8.4	1.682 400
0.9	20.644 882	4.7	3.442 120	8.5	1.656 526
1.0	18.512 817	4.8	3.358 141	8.6	1.631 273
1.1	16.768 631	4.9	3.277 634	8.7	1.606 623
1.2	15.315 344	5.0	3.200 388	8.8	1.582 551
1.3	14.085 828	5.1	3.126 211	8.9	1.558 041
1.4	13.032 135	5.2	3.054 929	9.0	1.536 074
1.5	12.119 089	5.3	2.986 375	9.1	1.513 630
1.6	11.320 328	5.4	2.920 398	9.2	1.491 693
1.7	10.615 692	5.5	2.856 858	9.3	1.470 246
1.8	9.989 471	5.6	2.795 623	9.4	1.449 275
1.9	9.429 295	5.7	2.736 571	9.5	1.428 763
2.0	8.925 260	5.8	2.679 591	9.6	1.408 697
2.1	8.469 336	5.9	2.624 577	9.7	1.389 061
2.2	8.054 968	6.0	2.571 429	9.8	1.369 843
2.3	7.676 740	6.1	2.520 057	9.9	1.351 032
2.4	7.330 125	6.2	2.470 374	10.0	1.332 613
2.5	7.011 335	6.3	2.422 301	10.1	1.314 576
2.6	6.717 152	6.4	2.375 760	10.2	1.296 908
2.7	6.444 851	6.5	2.330 679	10.3	1.279 601
2.8	6.192 079	6.6	2.286 995	10.4	1.262 642
2.9	5.956 818	6.7	2.244 645	10.5	1.246 021
3.0	5.737 318	6.8	2.203 569	10.6	1.229 731
3.1	5.532 049	6.9	2.163 712	10.7	1.213 759
3.2	5.339 687	7.0	2.125 018	10.8	1.198 099
3.3	5.159 047	7.1	2.087 443	10.9	1.182 741
3.4	4.989 097	7.2	2.050 938	11.0	1.167 677
3.5	4.828 927	7.3	2.015 459	11.1	1.152 900
3.6	4.677 715	7.4	1.980 965	11.2	1.138 399
3.7	4.534 738	7.5	1.947 412	11.3	1.124 170
3.8	4.399 342	7.6	1.914 772	11.4	1.110 206

100 ϱ_∞ or 100 R_∞	***K*/*S***	**100 ϱ_∞ or 100 R_∞**	***K*/*S***	**100 ϱ_∞ or 100 R_∞**	***K*/*S***
11.5	1.096 498	15.6	0.694 086	19.7	0.470 756
11.6	1.083038	15.7	0.687 088	19.8	0.466 595
11.7	1.069 823	15.8	0.680 186	19.9	0.462 480
11.8	1.056846	15.9	0.673 380	20.0	0.458 413
11.9	1.0441	16.0	0.666 667	20.1	0.454 392
12.0	1.03158	16.1	0.660 046	20.2	0.450 416
12.1	1.019278	16.2	0.653 515	20.3	0.446 485
12.2	1.007192	16.3	0.647 072	20.4	0.442 598
12.3	0.995 314	16.4	0.640 715	20.5	0.438 755
12.4	0.983 641	16.5	0.634 444	20.6	0.434 955
12.5	0.972 166	16.6	0.628 256	20.7	0.431 197
12.6	0.960 885	16.7	0.622 150	20.8	0.427 480
12.7	0.949 795	16.8	0.616 125	20.9	0.423 804
12.8	0.38 890	16.9	0.610 178	21.0	0.420 168
12.9	0.928 165	17.0	0.604 309	21.1	0.416 573
13.0	0.917 616	17.1	0.598 516	21.2	0.413 016
13.1	0.907 240	17.2	0.592 798	21.3	0.409 498
13.2	0.897 033	17.3	0.587 154	21.4	0.406 018
13.3	0.886 990	17.4	0.581 581	21.5	0.402 575
13.4	0.877 109	17.5	0.576 080	21.6	0.399 170
13.5	0.867 384	17.6	0.570 648	21.7	0.395 800
13.6	0.857 813	17.7	0.565 285	21.8	0.392 467
13.7	0.848 393	17.8	0.559 988	21.9	0.389 169
13.8	0.839 120	17.9	0.554 759	22.0	0.385 906
13.9	0.829 990	18.0	0.549 594	22.1	0.382 677
14.0	0.821 002	18.1	0.544 493	22.2	0.379 482
14.1	0.812 151	18.2	0.539 455	22.3	0.376 321
14.2	0.803 435	18.3	0.534 478	22.4	0.373 192
14.3	0.794 850	18.4	0.529 563	22.5	0.370 097
14.4	0.786 395	18.5	0.524 707	22.6	0.367 033
14.5	0.778 066	18.6	0.519 10	22.7	0.364 000
14.6	0.769 861	18.7	0.515 170	22.8	0.360 999
14.7	0.761 777	18.8	0.510 488	22.9	0.358 029
14.8	0.753 812	18.9	0.505 861	23.0	0.355 089
14.9	0.745 963	19.0	0.501 289	23.1	0.352 179
15.0	0.738 228	19.1	0.496 772	23.2	0.349 299
15.1	0.730 605	19.2	0.492 308	23.3	0.346 448
15.2	0.723 091	19.3	0.487 896	23.4	0.343 625
15.3	0.715 684	19.4	0.483 536	23.5	0.340 831
15.4	0.708 382	19.5	0.479 226	23.6	0.338 065
15.5	0.701 184	19.6	0.474 967	23.7	0.335 326

100 ϱ_∞ or 100 R_∞	***K/S***	**100 ϱ_∞ or 100 R_∞**	***K/S***	**100 ϱ_∞ or 100 R_∞**	***K/S***
23.8	0.332 615	28	0.239 338	32.1	0.176 487
23.9	0.329 931	28.1	0.237 527	32.2	0.175 206
24.0	0.327 273	28.2	0.235 732	32.3	0.173 936
24.1	0.324 641	28.3	0.233 953	32.4	0.172 676
24.2	0.322 036	28.4	0.232 189	32.5	0.171 426
24.3	0.319 455	28.5	0.230 441	32.6	0.170 186
24.4	0.316 901	28.6	0.228 708	32.7	0.168 955
24.5	0.314 370	28.7	0.226 990	32.8	0.167 735
24.6	0.311 865	28.8	0.225 288	32.9	0.166 524
24.7	0.309 384	28.9	0.223 599	33.0	0.165 323
24.8	0.306 926	29.0	0.221 926	33.1	0.164 132
24.9	0.304 493	29.1	0.220 267	33.2	0.162 950
25.0	0.302 082	29.2	0.218 622	33.3	0.161 777
25.1	0.299 695	29.3	0.216 991	33.4	0.160 614
25.2	0.297 331	29.4	0.215 374	33.5	0.159 459
25.3	0.294 989	29.5	0.213 771	33.6	0.158 314
25.4	0.292 669	29.6	0.212 182	33.7	0.157 178
25.5	0.290 371	29.7	0.210 606	33.8	0.156 050
25.6	0.288 095	29.8	0.209 043	34.0	0.153 822
25.7	0.285 841	29.9	0.207 494	34.1	0.152 720
25.8	0.283 607	30.0	0.205 958	34.2	0.151 628
25.9	0.281 394	30.1	0.204 434	34.3	0.150 543
26.0	0.279 202	30.2	0.202 924	34.4	0.149 468
26.1	0.277 031	30.3	0.201 426	34.5	0.148 400
26.2	0.274 879	30.4	0.199 941	34.6	0.147 341
26.3	0.272 748	30.5	0.198 468	34.7	0.146 290
26.4	0.270 636	30.6	0.197 007	34.8	0.145 246
26.5	0.268 543	30.7	0.195 559	34.9	0.144 211
26.6	0.266 470	30.8	0.194 122	35.0	0.143 184
26.7	0.264 415	30.9	0.192 698	35.1	0.142 165
26.8	0.262 380	31.0	0.191 285	35.2	0.141 154
26.9	0.260 363	31.1	0.189 884	35.3	0.140 150
27.0	0.258 364	31.2	0.188 494	35.4	0.139154
27.1	0.256 383	31.3	0.187 116	35.5	0.138 165
27.2	0.254 420	31.4	0.185 749	35.6	0.137184
27.3	0.252 475	31.5	0.184 393	35.7	0.136 210
27.4	0.250 548	31.6	0.183 048	35.8	0.135 244
27.5	0.248 637	31.7	0.181 715	35.9	0.134285
27.6	0.246 744	31.8	0.180 392	36.0	0.133 334
27.8	0.244 868	31.9	0.179 079	36.1	0.132 389
27.9	0.243 008	32.0	0.177 778	36.2	0.131 451

100 ϱ_∞ or 100 R_∞	***K/S***	**100 ϱ_∞ or 100 R_∞**	***K/S***	**100 ϱ_∞ or 100 R_∞**	***K/S***
36.3	0.130 521	40.5	0.097 041	44.6	0.072 728
36.4	0.129 597	40.6	0.096 361	44.7	0.072 217
36.5	0.128 681	40.7	0.095 686	44.8	0.071 709
36.6	0.127 771	40.8	0.095 016	44.9	0.071 204
36.7	0.126 868	40.9	0.094 350	45.0	0.070 703
36.8	0.125 972	41.0	0.093 690	45.1	0.070 206
36.9	0.125 082	41.1	0.093 033	45.2	0.069 712
37.0	0.124 200	41.2	0.092 382	45.3	0.069 221
37.1	0.123 323	41.3	0.091 735	45.4	0.068 733
37.2	0.122 453	41.4	0.091 093	45.5	0.068 249
37.3	0.121 590	41.5	0.090 455	45.6	0.067 768
37.4	0.120 733	41.6	0.089 821	45.7	0.067 290
37.5	0.119 882	41.7	0.089 192	45.8	0.066 816
37.6	0.119 037	41.8	0.088 568	46.0	0.065 876
37.7	0.118 199	41.9	0.087 948	46.1	0.065 411
37.8	0.117 367	42.0	0.087 332	46.2	0.064 949
37.9	0.116 541	42.1	0.086 720	46.3	0.064 490
38.0	0.115 721	42.2	0.086 113	46.4	0.064 035
38.1	0.114 907	42.3	0.085 509	46.5	0.063 582
38.2	0.114 099	42.4	0.084 910	46.6	0.063 132
38.3	0.113 296	42.5	0.084 316	46.7	0.062 686
38.4	0.112 500	42.6	0.083 725	46.8	0.062 242
38.5	0.111 709	42.7	0.083 138	46.9	0.061 801
38.6	0.110 925	42.8	0.082 556	47.0	0.061 363
38.7	0.110 146	42.9	0.081 977	47.1	0.060 929
38.8	0.109 372	43.0	0.081 403	47.2	0.060 497
38.9	0.108 604	43.1	0.080 832	47.3	0.060 068
39.0	0.107 842	43.2	0.080 265	47.4	0.059 641
39.1	0.107 085	43.3	0.079 703	47.5	0.059 218
39.2	0.106 333	43.4	0.079 144	47.6	0.058 797
39.3	0.105 587	43.5	0.078 589	47.7	0.058 380
39.4	0.104 847	43.6	0.078 037	47.8	0.057 965
39.5	0.104 111	43.7	0.077 490	47.9	0.057 552
39.6	0.103 381	43.8	0.076 946	48.0	0.057 143
39.7	0.102 657	43.9	0.076 406	48.1	0.056 736
39.8	0.101 937	44.0	0.075 870	48.2	0.056 332
40.0	0.100 513	44.1	0.075 337	48.3	0.055 931
40.1	0.099 808	44.2	0.074 808	48.4	0.055 532
40.2	0.099 109	44.3	0.074 283	48.5	0.055 136
40.3	0.098 415	44.4	0.073 761	48.6	0.054 742
40.4	0.097 725	44.5	0.073 242	48.7	0.054 351

100 ϱ_∞ or 100 R_∞	*K*/*S*	100 ϱ_∞ or 100 R_∞	*K*/*S*	100 ϱ_∞ or 100 R_∞	*K*/*S*
48.8	0.053 963	53.0	0.039 757	57.1	0.029 178
48.9	0.053 577	53.1	0.039 464	57.2	0.028 954
49.0	0.053 194	53.2	0.039 173	57.3	0.028 731
49.1	0.052 813	53.3	0.038 884	57.4	0.028 509
49.2	0.052 435	53.4	0.038 597	57.5	0.028 289
49.3	0.052 059	53.5	0.038 311	57.6	0.028 070
49.4	0.051 686	53.6	0.038 028	57.7	0.027 853
49.5	0.051 315	53.7	0.037 746	57.8	0.027 637
49.6	0.050 947	53.8	0.037 466	58.0	0.027 209
49.7	0.050 581	53.9	0.037 188	56.1	0.026 998
49.8	0.050 217	54.0	0.036 912	56.2	0.026 787
49.9	0.049 856	54.1	0.036 637	58.3	0.026 578
50.0	0.049 497	54.2	0.036 364	58.4	0.026 371
50.1	0.049 141	54.3	0.036 093	58.5	0.026 164
50.2	0.048 787	54.4	0.035 824	58.6	0.025 959
50.3	0.048 435	54.5	0.035 557	58.7	0.025 756
50.4	0.048 085	54.6	0.035 291	58.8	0.025 553
50.5	0.047 738	54.7	0.035 027	58.9	0.025 352
50.6	0.047 393	54.8	0.034 765	59.0	0.025 153
50.7	0.047 050	54.9	0.034 504	59.1	0.024 954
50.8	0.046 710	55.0	0.034 245	59.2	0.024 757
50.9	0.046 372	55.1	0.033 988	59.3	0.024 561
51.0	0.046 036	55.2	0.033 732	59.4	0.024 367
51.1	0.045 702	55.3	0.033 478	59.5	0.024 174
51.2	0.045 370	55.4	0.033 226	59.6	0.023 982
51.3	0.045 041	55.5	0.032 975	59.7	0.023 791
51.4	0.044 714	55.6	0.032 726	59.8	0.023 601
51.5	0.044 388	55.7	0.032 479	59.9	0.023 413
51.6	0.044 065	55.8	0.032 233	60.0	0.023 226
51.7	0.043 744	55.9	0.031 989	60.1	0.023 040
51.8	0.043 426	56.0	0.031 746	60.2	0.022 855
52.0	0.042 794	56.1	0.031 505	60.3	0.022 672
52.1	0.042 481	56.2	0.031 265	60.4	0.022 490
52.2	0.042 171	56.3	0.031 027	60.5	0.022 309
52.3	0.041 862	56.4	0.030 791	60.6	0.022 129
52.4	0.041 555	56.5	0.030 556	60.7	0.021 950
52.5	0.041 251	56.6	0.030 323	60.8	0.021 772
52.6	0.040 948	56.7	0.030 091	60.9	0.021 596
52.7	0.040 647	56.8	0.029 860	61.0	0.021 421
52.8	0.040 349	56.9	0.029 632	61.1	0.021 247
52.9	0.040 052	57.0	0.029 404	61.2	0.021 074

$100\ \varrho_\infty$ or $100\ R_\infty$	K/S	$100\ \varrho_\infty$ or $100\ R_\infty$	K/S	$100\ \varrho_\infty$ or $100\ R_\infty$	K/S
61.3	0.020 902	65.5	0.014 623	69.6	0.009 994
61.4	0.020 731	65.6	0.014 494	69.7	0.009 897
61.5	0.020 562	65.7	0.014 365	69.8	0.009 800
61.6	0.020 393	65.8	0.014 238	70.0	0.009 609
61.7	0.020 226	65.9	0.014 112	70.1	0.009 515
61.8	0.020 060	66.0	0.013 986	70.2	0.009 421
61.9	0.019 894	66.1	0.013 861	70.3	0.009 328
62.0	0.019 730	66.2	0.013 737	70.4	0.009 235
62.1	0.019 567	66.3	0.013 614	70.5	0.009 143
62.2	0.019 405	66.4	0.013 492	70.6	0.009 052
62.3	0.019 245	66.5	0.013 371	70.7	0.008 962
62.4	0.019 085	66.6	0.013 250	70.8	0.008 872
62.5	0.018 926	66.7	0.013 130	70.9	0.008 783
62.6	0.018 768	66.8	0.013 011	71.0	0.008 694
62.7	0.018 612	66.9	0.012 893	71.1	0.008 606
62.8	0.018 456	67.0	0.012 776	71.2	0.008 519
62.9	0.018 301	67.1	0.012 659	71.3	0.008 432
63.0	0.018 148	67.2	0.012 544	71.4	0.008 346
63.1	0.017 995	67.3	0.012 429	71.5	0.008 261
63.2	0.017 844	67.4	0.012 314	71.6	0.008 176
63.3	0.017 693	67.5	0.012 201	71.7	0.008 092
63.4	0.017 543	67.6	0.012 089	71.8	0.008 008
63.5	0.017 395	67.7	0.011 977	71.9	0.007 925
63.6	0.017 247	67.8	0.011 866	72.0	0.007 843
63.7	0.017 101	67.9	0.011 755	72.1	0.007 761
63.8	0.016 955	68.0	0.011 646	72.2	0.007 680
64.0	0.016 667	68.1	0.011 537	72.3	0.007 600
64.1	0.016 524	68.2	0.011 429	72.4	0.007 520
64.2	0.016 382	68.3	0.011 322	72.5	0.007 441
64.3	0.016 241	68.4	0.011 215	72.6	0.007 362
64.4	0.016 101	68.5	0.011 110	72.7	0.007 284
64.5	0.015 962	68.6	0.011 005	72.8	0.007 206
64.6	0.015 824	68.7	0.010 900	72.9	0.007 129
64.7	0.015 687	68.8	0.010 797	73.0	0.007 053
64.8	0.015 551	68.9	0.010 694	73.1	0.006 977
64.9	0.015 416	69.0	0.010 592	73.2	0.006 902
65.0	0.015 281	69.1	0.010 490	73.3	0.006 827
65.1	0.015 148	69.2	0.010 390	73.4	0.006 753
65.2	0.015 015	69.3	0.010 290	73.5	0.006 679
65.3	0.014 883	69.4	0.010 190	73.6	0.006 606
65.4	0.014 753	69.5	0.010 092	73.7	0.006 534

100 ϱ_{∞} or 100 R_{∞}	***K/S***	**100 ϱ_{∞} or 100 R_{∞}**	***K/S***	**100 ϱ_{∞} or 100 R_{∞}**	***K/S***
73.8	0.006 462	77.9	0.003 952	82.0	0.002 183
73.9	0.006 390	78.0	0.003 900	82.1	0.002 148
74.0	0.006 319	78.1	0.003 849	82.2	0.002 113
74.1	0.006 249	78.2	0.003 799	82.3	0.002 078
74.2	0.006 179	78.3	0.003 749	82.4	0.002 044
74.3	0.006 110	78.4	0.003 699	82.5	0.002 011
74.4	0.006 041	78.5	0.003 650	82.6	0.001 977
74.5	0.005 973	78.6	0.003 602	82.7	0.001 944
74.6	0.005 906	78.7	0.003 553	82.8	0.001 911
74.7	0.005 838	78.8	0.003 505	82.9	0.001 879
74.8	0.005 772	78.9	0.003 458	83.0	0.001 847
74.9	0.005 706	79.0	0.003 411	83.1	0.001 815
75.0	0.005 640	79.1	0.003 364	83.2	0.001 784
75.1	0.005 575	79.2	0.003 318	83.3	0.001 753
75.2	0.005 511	79.3	0.003 272	83.4	0.001 722
75.3	0.005 447	79.4	0.003 227	83.5	0.001 692
75.4	0.005 383	79.5	0.003 182	83.6	0.001 661
75.5	0.005 320	79.6	0.003 137	83.7	0.001 632
75.6	0.005 258	79.7	0.003 093	83.8	0.001 602
75.7	0.005 196	79.8	0.003 049	83.9	0.001 573
75.8	0.005 134	79.9	0.003 006	84.0	0.001 544
75.9	0.005 073	80.0	0.002 963	84.1	0.001 516
76.0	0.005 013	80.1	0.002 920	84.2	0.001 488
76.1	0.004 952	80.2	0.002 878	84.3	0.001 460
76.2	0.004 893	80.3	0.002 836	84.4	0.001 432
76.3	0.004 834	80.4	0.002 795	84.5	0.001 405
76.4	0.004 775	80.5	0.002 754	84.6	0.001 378
76.5	0.004 717	80.6	0.002 713	84.7	0.001 352
76.6	0.004 659	80.7	0.002 673	84.8	0.001 325
76.7	0.004 602	80.8	0.002 633	84.9	0.001 300
76.8	0.004 545	80.9	0.002 593	85.0	0.001 274
76.9	0.004 489	81.0	0.002 554	85.1	0.001 248
77.0	0.004 433	81.1	0.005 515	85.2	0.001 223
77.1	0.004 378	81.2	0.002 477	85.3	0.001 199
77.2	0.004 323	81.3	0.002 439	85.4	0.001 174
77.3	0.004 269	81.4	0.002 401	85.5	0.001 150
77.4	0.004 215	81.5	0.002 364	85.6	0.001 126
77.5	0.004 161	81.6	0.002 327	85.7	0.001 103
77.6	0.004 108	81.7	0.002 290	85.8	0.001 079
77.7	0.004 056	81.8	0.002 254	85.9	0.001 056
77.8	0.004 003	81.9	0.002 218	86.0	0.001 034

$100\,\varrho_\infty$ or $100\,R_\infty$	*K*/*S*	$100\,\varrho_\infty$ or $100\,R_\infty$	*K*/*S*	$100\,\varrho_\infty$ or $100\,R_\infty$	*K*/*S*
86.1	0.001 011	89.4	0.000 424	92.7	0.000 100
86.2	0.001 989	89.5	0.000 410	92.8	0.000 094
86.3	0.000 967	89.6	0.000 397	92.9	0.000 088
86.4	0.000 946	89.7	0.000 384	93.0	0.000 082
86.5	0.000 924	89.8	0.000 371	93.1	0.000 077
86.6	0.000 903	89.9	0.000 359	93.2	0.000 071
86.7	0.000 883	90.0	0.000 346	93.3	0.000 066
86.8	0.000 862	90.1	0.000 334	93.4	0.000 061
86.9	0.000 842	90.2	0.000 322	93.5	0.000 057
87.0	0.000 822	90.3	0.000 311	93.6	0.000 052
87.1	0.000 802	90.4	0.000 300	93.7	0.000 048
87.2	0.000 783	90.5	0.000 288	93.8	0.000 044
87.3	0.000 764	90.6	0.000 278	93.9	0.000 040
87.4	0.000 745	90.7	0.000 267	94.0	0.000 036
87.5	0.000 727	90.8	0.000 257	94.1	0.000 032
87.6	0.000 708	90.9	0.000 246	94.2	0.000 029
87.7	0.000 690	91.0	0.000 236	94.3	0.000 026
87.8	0.000 673	91.1	0.000 227	94.4	0.000 023
87.9	0.000 655	91.2	0.000 217	94.5	0.000 020
88.0	0.000 638	91.3	0.000 208	94.6	0.000 017
88.1	0.000 621	91.4	0.000 199	94.7	0.000 015
88.2	0.000 604	91.5	0.000 190	94.8	0.000 013
88.3	0.000 588	91.6	0.000 181	94.9	0.000 011
88.4	0.000 572	91.7	0.000 173	95.0	0.000 009
88.5	0.000 556	91.8	0.000 164	95.1	0.000 007
88.6	0.000 540	91.9	0.000 156	95.2	0.000 006
88.7	0.000 525	92.0	0.000 149	95.3	0.000 004
88.8	0.000 509	92.1	0.000 141	95.4	0.000 003
88.9	0.000 494	92.2	0.000 134	95.5	0.000 002
89.0	0.000 480	92.3	0.000 127	95.6	0.000 001
89.1	0.000 465	92.4	0.000 120	95.7	0.000 001
89.2	0.000451	92.5	0.000 113	95.8	0.000 000
89.3	0.000 437	92.6	0.000 106		

ANNEX F

(*Foreword*)

EXPERTS WHO MADE SIGNIFICANT CONTRIBUTION TO THE DEVELOPMENT OF THIS STANDARD

Organization	*Representative(s)*
In Personal Capacity	Prof A. S. Khanna, (***Chairman***), CHD 21
Harcourt Butler Technical University, Kanpur	Dr P. K. Kamani Dr Arun Maithani (*Alternative*)
Aditya Birla	Dr P. S. Samant
Asian Paints Ltd, Mumbai	Mr. Rajeev Kumar Goel Dr Subrahmanya Shreepathi (*Alternative*)
Akzo Nobel India, Thane	Shri Dhirendra Kumar Shri Kaustav Chatterjee (*Alternative*)
Atul Limited	Shri Jayesh N Patel
Berger Paints India Limited, Kolkata	Dr T. K. Dhar Shri Swagata Chakraborty (*Alternative*)
BASF India Ltd, Mumbai	Shri V. Selva Kumar Shri Kirit Doshi (*Alternative*)
Covestro (formerly Bayer material science)	Nomination Awaited
Clariant Chemicals (India) Ltd, New Delhi	Shri Nitin Vaidya Shri Umesh Kapoor (*Alternative*)
English Indian Clays Ltd, Kerala	Shri S. V. Kamalesh
Heubach India, Mumbai	Shri J. I. Sevak
Hempel Paints India Pvt Ltd, R&D centre, Nashik	Shri Keyur Shah
Hindustan Zinc Limited, Delhi	Priya Chauhan
M/s Huntsman	Shri Ravindra Mukavar
ICT, Mumbai	Prof Sabnis Prof Mehanuvar (*Alternative*)
Indian Paint and Coating Association, New Delhi	Shri Ashvini Mehra Shri D. Batra (*Alternative*)
Indian lead zinc development association, New Delhi	Shri K. Sridhar
Indian Small Scale Paint Association	Shri Mukund Hulyalkar
Indian Institute of Chem Technology, Hyderabad	Dr Ramanuj Narayen Dr Pratyay Basak
Institute of Science and Technology for Advanced Studies and Research (ISTAR)	Dr Kalpesh Patel (Young Professional) Dr Parag Shantilal Karia) (*Alternative*)
Indian Resin Manufacturer Association	Nomination Awaited
Kansai Nerolac Paints Ltd, Mumbai	Shri Amrit Rekhi
National Test House, Ghaziabad	Nomination Awaited
Office of Micro, Small & Medium Enterprises, New Delhi	Shri Sunil Kumar Newar Shri Santosh Kumar
Research Designs & Standards Organization, Lucknow	Nomination Awaited
Shalimar Paints Limited (M)	Shri Girish Mehendale
Shriram Institute of Industrial Research	Shri A. K. Majumdar

Organization	*Representative(s)*
SSPC India Chapter	Dr Buddhadeb Duari Young Professionals Subhajit Bhattacharya (*Alternative* I) Kaushik Duari (*Alternative* II)
20 Microns Limited, Mumbai	Dr Anil Bansal
Transpek Industry Limited, Vadodara	Shri Anil Bajpai
University Institute of Chemical Technogy, Jalgaon	Prof Ravindra Puri
Vapi Oxide Colours Pvt Ltd (VOXCO), Vapi	Shri Ishan Raveshia
VOICE (O)	Shri M. A. U. Khan Shri B. K. Mukhopadhaya (*Alternative*)
Directorate General, BIS	Shri A. K. Lal, Scientist 'E' and Head (CHD) [Representing Director General (*Ex-officio*)]

Member Secretary

Sagar Singh
Scientist 'C' (CHD), BIS

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